CENTRAL INTELLIGENCE AGENCY

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PROJECT FLUSE

1. Project Fluse concerned the experimental utilization of a heated flow propulsion plant for the propulsion of a remote-controlled missile within supersonic regions. However, a special characteristic, the absence of wings, is noted in contrast to the Lorin-Jet, whose principal construction feature is a diffuser-jet at the air intake, which gradually expands and causes the subsonic air stream to be retarded with a simultaneous increase of pressure. The exhaust jet is gradually reduced aft of the combustion chamber. The prefixes for the dimensions provided in this project should be considered with inverted values since here the air stream enters at supersonic velocities (Mach 1.1 to 2.2). First of all, a reduction in velocity must be accomplished. This is done by gradual reduction of the intake dimensions, which simultaneously increases the air pressure. This also increases the time element of gases passing through the combustion zone, according to the reaction time of the fuel, to as great an extent as necessary. The shape of the jet section was designed in such a manner that the velocity within the narrowest section never dropped below that of sound after the missile had attained, with the aid of several starting rockets (inclusive of the auxiliary starting rocket within the stern), a velocity of 360 meters per second. Consequently, the flow must increase

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again after the critical section (sic), with a corresponding loss of pressure. The construction was designed with such a shape as to provide the critical section with a multitude of very small perforations (fuel jet-grid).

2. Fuel was to be spread in vaporized feed under pressure of from 30 to 10 atmospheres through this device. At the same time, the mixture of the droplets within the supersonic flow produces an ignitable sort of fog. However, the temperature increase attained in the forward part of the jet would not yet be sufficient to cause combustion. For this reason, it was intended to introduce in the critical cross section six rows of two each of powder gas streams distributed over the complete cross-sectional area and orientated vertically to the direction of flow within the cross-sectional area. This continuous ignition is of importance in dealing with a thermodynamic process. Without it, because of the supersonic velocities near the critical cross section, the flame would have been blown out of the rear of the jet. Now, because of combustion taking place near the critical cross section, no reduction in pressure takes place within the greatly increased width behind the critical cross section. The pressure is held constant and increased with a simultaneous increase of exhaust pressure. Prior to exhaustion of the hot combustion gases in the atmosphere, a further reduction of pressure to nearly that of the surrounding atmosphere takes place within the greatly expanded stern part. However, the exhaust velocity considerably surpasses the intake velocity.

3. The cross-sectional drawings of design Fluse do not maintain an absolute validity (see diagram, page 10). A proper dimensioning presupposes extended preparatory calculations, whereas the final shape may be ascertained only after pressure and temperature measurements have been made on models. In this connection, it is to be noted that during the designing of this project, the special difficulties that arose during retardation of supersonic velocities were known. For purposes of experimentation, the utilization of several angular compression thrusts rather than one strong linear thrust, for reasons of better performance characteristics, was tried. However, as is now known, such designs are only applicable at certain Mach numbers and any minute deviation from the nominal values causes considerable difficulty. Furthermore, the principle of angular compression shocks may be utilized under certain conditions, since the arrangement of the rudder fins, for reason of stability, necessarily far removed from the intake opening, can only be placed within the region of the jet covering at extremely high Mach numbers.

4. Concerning aerodynamics, utilization of special wings was dispensed with because, according to previously executed experiments, sufficient lift values were obtained by a comparatively minute angle of attack of the jet housing. In order to avoid reactions on the rudders, and in order to utilize all lift forces in a positive direction, the Rheintochter method, which is a proven design (rudders at the front of the missile), was adopted. Further consideration of the project without exhaustive measurement technique (sic) in wind tunnels and thermodynamic test runs was declined by me. How far the basic idea within this shape is to be realized cannot, even today, be foretold without such experiments. Should it appear that, notwithstanding the powder-ignition-stream, no continuous ignition is obtainable, then there always remains the possibility of increasing the compression within the intake jet to such an extent that the velocity is led over a straight thrust into subsonic regions. Then, at the conclusion of the combustion region, prior to entering the expansion jet, a cross-sectional reduction is included in such a manner as to produce sonic velocity and is considerably surpassed in the aft part of the duct.

5. Within the scope of the first project for the Ministry of Shipbuilding Industry, a universal missile was supposed to have been created at a maximum weight of 1,000 kilograms that should have been usable against rapid air targets at heights up to 18 kilometers as well as against maritime targets over distances up to 50 kilometers. For launching from on board battle cruisers, a mounting platform, such as for Rheintochter, was envisaged, whereby the control was intended to be coincidental to the target flight path. During further work on the problem, the weight was lowered to about 650 kilograms whereby the launching did not occur from a directable launching mount but out of a floating buoy. It was supposed to have been dropped overboard together with the projectile such as a water mine, which is dropped across the stern of a vessel. It would then position itself vertically within the buoy.

DETAILED DESCRIPTION OF PROJECT

6. On the inside is the central, slender, tapered body, around which is drawn a six-edged duct cover made of deep-drawn metal approximately one and one-half millimeters thick (see diagram, page 10). Six longitudinal spars form the frame for this covering. At the tip of the central body is the beard antenna for the electrical minimum igniter. The minimum fuse causes ignition and detonation of the explosive charge as soon as the minimum distance from the target is reached. The rudder equipment consists of four single rudder blades arranged at 90 degree angles to each other. Each rudder is adjustable with the twin-vane servo unit with a special amplifier within the flange plate. Since the control parts are specifically light in weight, the explosive charge is placed here so as to move the center of gravity as far forward as possible. Except for this, it would have been desirable to accomodate the explosive charge in the rear of the missile. The explosive charge itself was approximately 150 kilograms. There were different variations with larger and smaller charges. In general, there were supposed to have been about 1,000 incendiary fragments incorporated. In front of the head, the actual control equipment was located. The damped directional gyro, as in the Rheintochter, was located in the center. The batteries formed a ring around the control compartment of the missile. These batteries could be charged, even in assembled condition, so that they are fully charged when the missile is launched. Behind this protectively-arranged chassis plate is the direct current (three-phase alternating current transformer-inverter - Gleichstrom-Drehstrom Umformer) which produces a frequency of 500 kilocycles for the gyro. The inverter is driven by the battery current of 24 volts. One phase of this three-phase A.C. inverter is used for the operation of the radio receiver of the type Strassburg or Kolmar, whereby the main voltage produced in the transformer-inverter of approximately 220 volts is transformed in the meantime by an appropriate rectifier to the necessary anode voltage. Directly behind the control equipment is a round tank-like container with a capacity of approximately 300 dm^3. This container holds a carbohydrate (benzol-like or gasoline-like propellant).

7. It was endeavored to use no especially ethereal substance, keeping in mind the possibility of switching to diesel fuel or some gaseous oil. How far this would be possible had to be ascertained by combustion experiments, because a change of fuels was dependent upon the flash temperature, ignitability, reaction time, etc., of the fuels. The intention was to use diesel oil, although it is a poor inflammable fuel. There were also experiments on highly-evaporable fuels that offered better firing temperatures for the over-all operation. The fuel container had a provision for a Schnorkel-like draw pipe, a flexible hose that reached to the bottom of the tank. During operation, while the original acceleration takes place by means of starting rockets, the fuel mass will position itself toward the stern of the fuselage, causing the air bubble to shift forward. During this period, electrical ignition is utilized.

8. Carbon dioxide or another inert gas was also used as a driving force. The driving media (the gas) is contained within a high-pressure flask. This high-pressure flask could contain approximately 10 liters at a working pressure of 300 kilograms per square centimeter. It was possible to lower the mass pressure within the fuel container during extrusion of the last remnant in the container to about 10 kilograms per square centimeter. The actuation was planned in such a way that, immediately after burning of the starting rockets, a luminar disc was destroyed by an automatic electrical ignition, controlled by a delay-relay, so that the pressure within the flask (300 kg/cm^2) was reduced to a working pressure of about thirty to ten atmospheres through a reduction valve positioned alongside. At the same time, it was planned to have the reduction valve built as a program reduction valve. Depending upon the internal pressure of the storage tank, it would then cause a corresponding discharge pressure. Thus, to some extent, was the possibility afforded to equalize various air densities during acute climb, so that at any time, the more advantageous amount of fuel could be forced into the injection jet. The installed starting rocket had a charge of approximately 60 kilograms, which alone was unable to produce the necessary acceleration. It was necessary to have a starting velocity of at least 360 meters per second before this supersonic propulsion unit would begin to function. The installation of this auxiliary rocket was planned more or less for the reason that the space was free. This space would have been unsatisfactory for any steering components since a greater part of the steering (control) components were housed in the forward part. The Germans endeavored to combine all control components upon one chassis. They reasoned that, during any kind of control, the whole chassis would be pulled and a general test could just as well start here. It would have led to difficulties if part of the control equipment were placed forward and part in the rear. Experiments in the wind tunnel showed the neutral point of the body. Eventually the possibility arose that, by corresponding design changes in construction, the neutral point could be shifted to such an extent that the rear space could be utilized for extra booster rockets.

9. The central body had six ribs (see diagram, page 10). These tubular ribs have a diameter of approximately 30 millimeters and a wall thickness of 3-4 millimeters. It was planned to place an additional rocket drive charge inside the ribs. These charges were

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At this point ignition of the ignitable mixture is started. The gases are first heated. This leads to an increase in pressure, then to an additional increase of velocity (see top, heavy black curved lines in diagram, page 10). There is only a reasonable after-burning within the next stage, noted here by a small increase in velocity and a small drop in pressure. This could result in a variation of either a small gain or small loss. It is also possible that the pressures in this section remained constant. Thus, after passage of the gases through the rear support brackets (arranged in a triangular shape in contrast to the front ones, which are sloped toward the rear at an obtuse angle and which, from a flow point of view, are constructed with lack of efficiency), it is possible to attain a longer time lapse, during which the spark will glow and perhaps provide for better ignition of the fuel mixture. Because of the construction of the front support brackets, the turbulence in front was tolerated. The symmetrical construction of the rear supports has proven beneficial for a supersonic flow. In the last stage, there is a sudden contraction of the cylindrical core and a further continuation of the jet jacket in the same direction as the forward part. Thus, both parts offer a substantial increase in cross-sectional dimension again. During the consideration of this constant pressure, it was known that it is not a simple matter to retard a flow of air within supersonic velocity ranges by ordinary means in order to create an increase in pressure because the danger of compression shocks is very great. In dealing with the rudder parts and components of this nature, it became obvious that it would not be possible to count on full velocity for the parts in the rear. It was hoped that because of the comparative slender finishing, it would be possible to hold losses to tolerable limits. It is to be noted that the model (see diagram, page 10) does not represent an absolutely exact reproduction of the model then on hand. [redacted] The former model attempted to utilize the benefits of an oblique shock within the front parts, that is, in the front part of the central body in the direction of the Mach angle, a deflection of the current groups was caught and again experienced a diversion on the other side at the point of incidence. Thus, by serially arranging several oblique compression shocks, the losses of transfer of supersonic velocities to more possible velocities within reasonable limits were eliminated. 25X1 25X1 25X1

11. Experiments were planned for the wind tunnel and with a thermodynamic combustion unit to determine from the results what would be feasible or how much basic difficulty might be expected. Calculations proved that no further supporting wings would be necessary because of the specific light weight of the object and in view of the external dimension of the exhaust jet. A relatively small change in angle of elevation causes great diagonal forces, as expected with the present rudder installation of the canard type. This in turn results in comparatively great lift forces. The Germans were able to produce good maneuverability with this type missile. For practical purposes, four single rudder machines are provided for in this twin rudder model so that each surface can be controlled individually. But where the drive motors make a mixing of the individual impulses possible by means of an electrical control part, i.e., even without externally-originating radio impulses but by

means of the gyro alone, a stabilization along the longitudinal axis was certain. With this object, it was not necessary to stabilize for roll. By proper switching arrangement of the electronic commands, it was possible to transmit such commands to the control section of whichever rudder group might need it. However, this presupposes that the gyration does not increase to such extent that continuous variations could not be coped with by the control mechanism. But, with the gyration as small as it was expected to be, there was no hesitation to use the system which was previously planned for Rheintochter. Pre-stressed sheet metal, 1.5 millimeters thick, was secured to the longitudinal tubes to form a closed cover. The cover could be moved toward the rear and, by means of spot welding, was secured to the tubular frame members. The main difficulty with this system lay in the fact that certain and continuous combustion within the prescribed combustion path could not be counted on. The usual form of the Lorin-Jet, contrary to subsonic principles, is not of proper construction. The Fluse has a comparatively small entry opening which, immediately after the throat, widens into the combustion chamber, and is either kept cylindrical or again offers an increase in width. The intake was designed primarily for subsonic velocities, but with the possibility that it could be utilized for supersonic velocities. Through the throat the air stream approaches subsonic velocities at a Mach number of approximately .08 or .09. In this manner, the velocity is lowered because of an increase in pressure. The air enters the Lorin-Jet at about 260 meters per second. The pressure now remains practically constant and the injection of fuel takes place simultaneously. Then a heating of the gases takes place. This would normally increase the velocity but, by means of complimentary heating, the velocity is held to about this magnitude. During the last stage, an acceleration again takes place and causes an increase equal to or perhaps somewhat above the original velocity. That by itself would be the Lorin-Jet. Just the reverse is the case with athodyds (ramjets). In front the throat is widened and, even in the first stage, it is still widening, only to narrow down at the end. Here it was planned for the intake to be used in supersonic velocity ranges by narrowing of the duct.

12. Next comes a gradual increase in width all the way to the rear where a choke is provided and then another expansion. With the Lorin-Jet, it was mainly planned to keep the velocity down to about 50 meters per second because the velocity of the flame front lies in the same range. However, if both velocities are in this neighborhood, ignition would take place and combustion would remain in the same latitude. No ignition would be possible at higher velocities. For this reason it was hoped that, with the aid of the auxiliary rocket that carried the glowing particles of aluminum into the jet stream, a continuous combustion process within the desired velocities or perhaps at greater-than-sonic speeds could be attained. When the velocity supersedes that of sound, it is possible to increase the velocity in later stages. With the added heat, it was possible to arrive at very high final velocities with a considerable over-all increase of momentum for the projectile. At first it might be thought that it is a Lorin-Jet, whereas actually it is just the opposite. The pressure will show as follows: first it was low; then correspondingly it increases in the first stage where it remains practically constant and, in the last section, it diminishes again to equal external pressure. At least it is a very interesting solution

and one that cannot be solved on the drawing table but only with combustion experiments. If an air stream, flowing at supersonic velocities, could be brought to stationary combustion so that at all times the flame front commences at a like velocity and if heating afterwards takes place, then this comparatively simple system could be constructed. Should the experiment have negative results, there is always the possibility of carrying the restriction further to produce a very small cross section so that in this section a compression shock appears and it is again back in the subsonic range of velocity. It would then be possible in later stages to arrange an enlarging of the cross section, but that would now cause a steady decline in velocity with corresponding increase of pressure. In order to fully utilize the velocity injected here, a contraction before the expansion jet on the stern would be necessary. In order to achieve this contraction, it would be necessary to further decrease the internal pressure while correspondingly accelerating the velocity at the narrowest cross section and arrive at a sonic speed that can, by corresponding pressure drop, be increased to corresponding supersonic velocities. That is, the same dimensions as are in the front part of the design might appear at the stern. Probably the over-all length would have to be increased from what is shown here.

13. These missiles were supposed to be fired from normal launching structures with 360 degrees traverse. This was an order that emanated from the People's Commisiariat for Marine Construction (now the Ministry of Shipbuilding Industry). In the course of time, the Germans were presented with the task of reducing the weight from 1,000 kilograms to 650 kilograms and lower yet if possible. As a firing instrument, no special launcher was supposed to be utilized as the opinion was that, on board a battle cruiser, all deck space would be fully utilized for the ship's artillery and that space was not to be wasted for launchers. For this reason, the launching was supposed to be accomplished as follows: the projectile was supposed to have been placed within a more or less cylindrical container in a floating buoy, and this buoy was supposed to have been thrown overboard in a manner similar to that of depth charges (by rolling overboard at the stern). Then the buoy would right itself point up because the center of gravity is low. By means of small charges, the cover cap could be removed and the projectile, with the aid of starting rocket, would launch itself in a vertical direction. In this way special precautionary measures would not have to be taken on board the vessel itself. The Germans actually worked out this problem and arrived at a constructive solution that could fulfill the demands of the problem which was not necessarily to be considered a forced solution. Naturally the guiding process would have to be orientated somewhat to the sides as the Germans were not able to shoot the projectile into the homing beam and had to "catch" the projectile in its vertical flight and only then gradually work it into the guide beam by means of radio control. But I cannot recall how this was effected. Theoretically, the Germans contemplated experiments that permitted good comparison of the various systems.

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14. It is to be noted that it was designed as a dual purpose weapon to be used with incendiary fragments against aircraft and against maritime (ships) targets. For maritime targets the missile, fitted with a special head, was supposed to create a certain submersion run and underwater detonation in the immediate vicinity of a ship. For fighting off ship targets, a minimum of 60-60 kilometers was demanded. This demand could not be met with the same instrument that usually was intended for a flight height of 18 kilometers. On the contrary, within 18 kilometers height, the total propulsion medium was not completely used up. The Germans had to increase the fuel containers for the 50-60 kilometers distance in order to be able to utilize the same missile at such a distance. It was now difficult to observe it over the 60 kilometers and here a relay service was planned where an aircraft was supposed to take over the intermediate observation. By means of the aircraft, the direct control and a corresponding greater line of flight were observed. [redacted] this.

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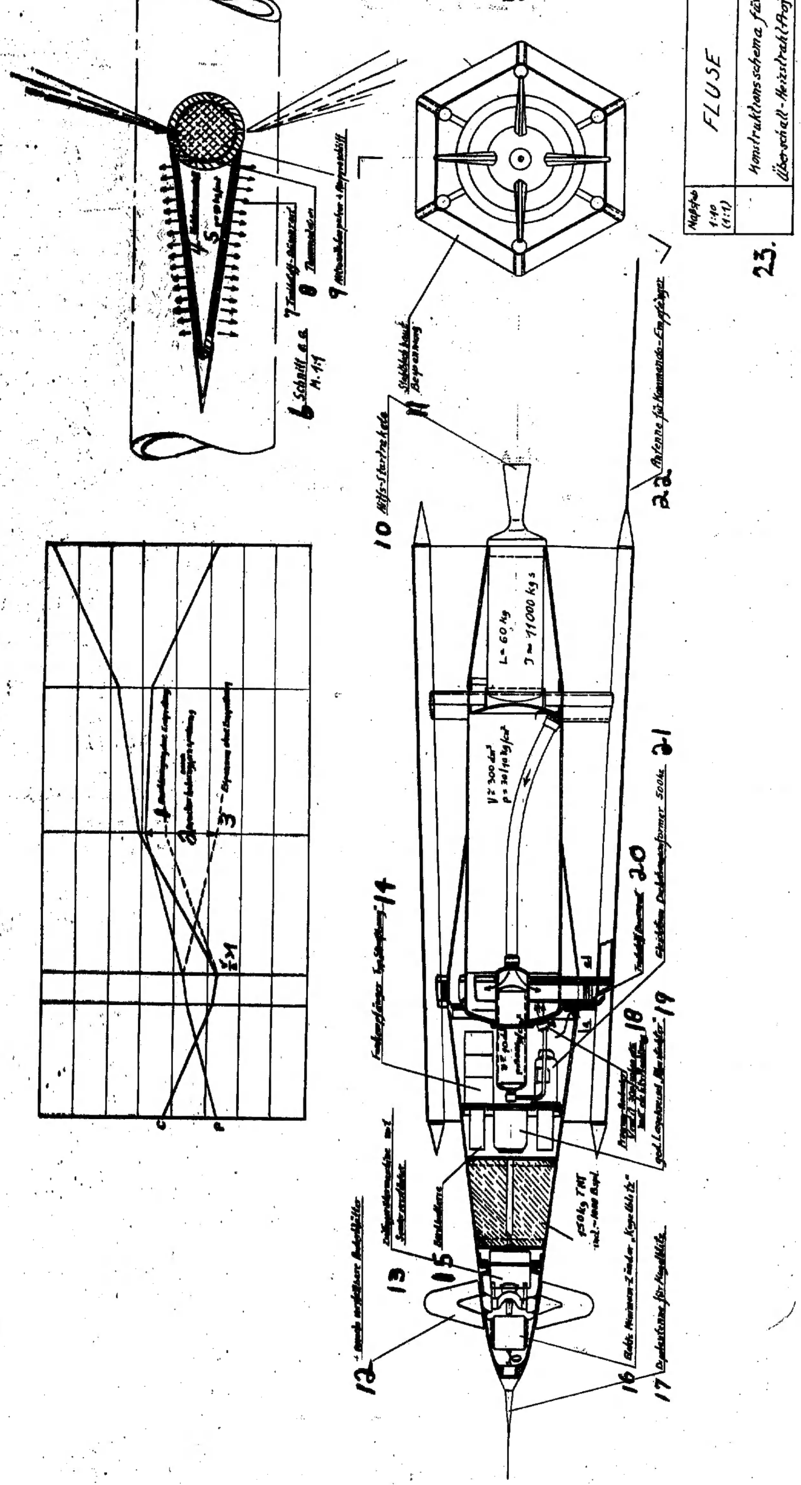

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Legend to Diagram, Page 10

Translation of Parts

1. Acceleration without injection.
2. Pressure Delivery through injection.
3. Expansion without injection.
4. Carbohydrate.
5. P = 10 Kg/cm.^{2}.
6. Cross Section
7. Propellant Grill.
8. Thermo Insulation.
9. Nitro Cellulose Powder + Aluminum fine cuts.
10. Starting Rocket.
11. Deep Drawn Sheet Steel Covering.
12. Four individual Rudder Blades.
13. Twin Servo Unit with Special Amplifier.
14. Radio-Transmitter Type Strassburg.
15. Gyro Batteries.
16. Electronic Minimum Igniter Kugelblitz (Kugelblitz - Code name for German Minimum Distance Igniter).
17. Dipole Antenna for Kugelblitz
18. Program Reducer Valve 300/30/10/Atmos. with electronic control.
19. Electronic Control Equipment from Rheintochter.
20. Propellant Grill.
21. Three Phase Trans-inverter 500 kc.
22. Antenna for Command Radio.
23. Design Schematic for Supersonic Heated Jet Projectile.